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**Description**

This invention relates to a linkage mechanism and assembly for transmitting first and second opposing actuating forces, and more particularly to a linkage mechanism for driving a work member, such as the jaws of a surgical forceps, between an open and a closed position.

There are a number of instruments in the prior art wherein distal jaws are remotely actuated to open and close them. Rather than rely on tiny pivot pins to hinge two jaws together, arcuate flanges and grooves pivotably interconnect the jaw members with a coupling member that also serves as an actuating member to drive the jaws together or apart, depending on the direction in which the coupling member is moved. Significant mechanical advantage is achieved by spreading the centers of rotation much farther apart than that which would be achieved using pivot pins mounted within the jaws.

German Utility Model G 90 10 804.3 is typical of the prior art and relates to a surgical instrument wherein the distal jaws are remotely actuated to open and close utilizing a coupling member that connects the movable portion of the jaw with a remote actuating member in combination with a traverse pin that permits a swinging movement of the swingable jaw against the fixed jaw part.

Because the coupling member described in the prior art is a solid, rigid element which extends from the movable jaw member to a handle mechanism, the coupling member itself rises and falls over its entire length during operation of the jaws. The coupling member rises and falls within an open groove in the instrument. This is acceptable for many surgical procedures including arthroscopic knee surgery, but does not provide a fluid-tight seal between the distal and proximal ends of the instrument.

A gas-tight seal is desirable in some procedures such as laparoscopy and other surgical operations in which a pressure differential exists between the interior and the exterior of a patient. The pressure differential therefore is experienced between the distal and proximal ends of a laparoscopic instrument.

A grasper and dissector surgical instrument for laparoscopy is in the prior art and available to the surgical community. The instrument has dual moving jaws which are connected together by a central pivot pin. Each movable jaw is separately interconnected by a pivot pin to the distal end of a link member. The two link members are interconnected at the proximal end with an actuator by a "T" projection of the actuator which fits into a recess within each link. The rise and fall motion of each link is relatively limited.

Therefore, it is one of the objects of the present invention to actuate the jaws of a surgical instrument while maintaining a gas-tight seal between the distal and proximal ends of the instrument.

It is a further object of the invention to provide a linkage mechanism which can carry an arcuate flange or groove at its distal end without defeating the gas-tight seal.

5 A further object of this invention is to provide a linkage mechanism which restricts rise and fall pivot action to a relatively short length of the overall instrument.

10 Another object of the invention is to provide such an instrument which enables convenient and repeated assembly and disassembly.

15 Yet another object of the invention is to provide an improved linkage assembly which limits deformation of an O-ring.

This invention results from the realization that an 20 improved gas-tight surgical instrument having powerful jaws can be achieved by restricting vertical rise and fall of pivoting action to a relatively short link that is movably interconnected at its distal end to a jaw member and is pivotably interconnected at its proximal end to an actuating member, and by utilizing a separate shoulder element to transmit a large force in one direction.

25 This invention features a link for transmitting actuating forces from an actuating member to a work member. The link includes a link body having a distal end and a proximal end. The distal end of the link body is movably interconnected with the work member by distal interconnection means such as an arcuate groove-and-flange assembly, and is interconnected at its proximal end by proximal pivotal interconnection means. The proximal 30 means transmits a first actuating force from the actuating member to the work member. A shoulder, disposed on the link body preferably between the distal and proximal means for interconnecting, engages the actuating member when a second, greater actuating force is applied to the actuating member in a direction opposite to that of the first actuating force. The greater force is thereby transmitted to the work member.

35 In one embodiment, the distal interconnection means includes either an arcuate flange or an arcuate groove for interlocking with an arcuate groove or an arcuate flange, respectfully, of the work member. Alternatively, the distal interconnection means is a pivot pin. The proximal means for interconnecting may include one or more projections extending from the link body to fit within corresponding recesses in the actuating member. Preferably, the distal interconnection means and the proximal interconnection means are formed integrally with the link body, which is formed of a metal such as stainless steel.

40 45 50 55 In a preferred embodiment the shoulder includes lateral projections extending from either side of the link body, each projection defining a concave proximal end face which engages matching convex surfaces of the actuating member to enable the rise and fall pivoting action of the link. The link may further include a stop element, associated with the distal interconnection means, for limiting movement of the work member relative to the link.

This invention also features a link assembly for driving a work member, the assembly including a link as described above and an actuating member with one or two distally projecting fingers. Each finger has a distal lead surface which engages a proximal end face of the shoulder to transmit a strong pushing force.

Preferably, the link assembly is disposed within a surgical instrument having one or two movable jaws which are interconnected with one or two links that are driven by a single actuating member.

Other objects, features and advantages will occur from the following description of a preferred embodiment and the accompanying drawings, in which:

Fig. 1 is a partial-cutaway side view of a surgical forceps incorporating a link assembly according to the present invention at its distal end and an actuator drive arrangement at its proximal end;

Fig. 2 is a schematic axonometric view of the link according to the present invention;

Fig. 3 is a partial cross-sectional view of the distal portion of the surgical forceps of Fig. 1;

Fig. 4 is a schematic top cross-sectional view of the actuator disposed within the distal portion of the outer tube and the proximal portion of the stationary jaw of the instrument and carrying an O-ring and a spacer;

Fig. 5 is a schematic partial top plan view illustrating assembly and disassembly of the link with respect to the two distal fingers of the actuator;

Figs. 6A and 6B are schematic top plan views showing the transmission of first and second actuation forces, respectively;

Fig. 7 is an axonometric view of the spacer;

Figs. 8A and 8B are schematic top and side views, respectively, of an alternative link assembly according to this invention;

Fig. 9 is a schematic partial-cross sectional top view of yet another link assembly having two links according to the present invention;

Figs. 10A and 10B are schematic side views of the assembly of Fig. 9 in the closed and open positions, respectively;

Fig. 11A and 11B are schematic side and top views, respectively, of another link assembly according to the subject invention in which the actuator projects into a slot in the link;

Fig. 12 is a partial cross-sectional view of yet another link assembly of the present invention in which the link defines a cavity into which a portion of the actuator projects;

Fig. 13 is an axonometric view of a still further link assembly of the present invention in which the link and actuator are coupled by an arcuate groove-and-flange arrangement; and

Figs. 14A and 14B are schematic axonometric views illustrating yet another link assembly of the present invention.

This invention may be accomplished by a link element, and an assembly using the link element, which transmits first and second actuating forces from an actuating member to a work member such as one or more jaws of a surgical instrument. The link is movably interconnected at its distal end with the work member and is pivotably interconnected at its proximal end with the actuating member. A first actuating force is transmitted from the actuating member to the work member through a proximal interconnection element.

A second, greater actuating force is transmitted by engagement between a shoulder of the link and a distal region of the actuating member. Alternatively, alone or in combination with a shoulder, a second curvilinear surface of the proximal interconnection element receives the second actuating force. For transmission of the second force, the actuating member defines a transmitting surface having a curvature which matches that of the link's second curvilinear surface to facilitate the vertical rise and fall of the link.

The link is especially useful in minimally invasive surgery such as laparoscopy. During laparoscopy, elongated instruments are passed through an elongated cannula, and a higher pressure differential is maintained within the patient by injection of a nontoxic gas to better expose tissue for the surgeon. A link assembly according to the present invention enables an actuator member to reciprocate linearly within a gas-tight instrument shaft without defeating a seal about the actuator member.

A surgical instrument 10 according to the present invention is shown in Fig. 1 having a link assembly 12, a proximal handle assembly 14, and a central elongated section 16. The center section 16 is established by an outer conduit 18 within which an actuator rod 20 reciprocates. The proximal end of the conduit 18 is secured to a handle body 22 of the handle assembly 14 by a set screw 24. The handle body 22 is a continuous piece which terminates in an arm 26. A recess 28 is formed within the handle body 22, extending distally from a proximal edge 30, shown in phantom. The recess 28 extends completely through the upper side of the handle body 22 between a proximal point 32 and a distal point 34 to accept the upper portion of a movable arm 36.

The configuration of the handle assembly 14 in this embodiment is similar to that described in the prior art. When movable lock 38 is slid upwardly, the movable arm 36 can be moved distally to pivot about pivot pin 40 to drive its upper portion proximally. The upper portion of the movable arm 36 contains a rounded U-shaped recess 41 which engages a proximal projection 42 of the actuating rod 20. A proximal recess 44 is provided in the actuating rod 20 to assist engagement with the movable arm 36. A second recess 46 is provided in the actuating rod 20 to receive a set screw 48 which serves as a stop to limit the reciprocating motion of the actuating rod 20.

The link assembly 12 in this embodiment comprises a stationary lower jaw 50 which is attached by soldering or welding to the distal portion of the conduit 18, and an upper movable jaw 52. The jaws 50, 52 serve as a toothed grasper in this construction; alternatively, other types of jaws for forceps, punches or other instruments can be utilized as described in the prior art.

The movable jaw 52 is interconnected with the actuating rod 20 by a link 54 according to the present invention, indicated in a phantom in Fig. 1. The link 54 is shown in greater detail in Fig. 2 after disassembly from the instrument 10. The link 54 includes a link body 60 having an arcuate flange 62 at its distal end for interconnection with the movable jaw 52, Fig. 1, and opposing projections 64, 65 for interconnection with the actuating rod 20 as described in more detail below.

The link 54 further includes an integral shoulder 66, Fig. 2, which projects laterally to either side of the link body 60. The shoulder 66 defines proximal curvilinear end faces 68, 70 which engage with the distal leading surfaces of the actuating rod 20, again as described in more detail below. Also described below is the function of a notch 72 during disassembly.

The interconnection of the arcuate flange 62 with a corresponding groove in the movable jaw is similar to that described in the prior art in which the distal end of the continuous coupling member carries an arcuate flange or groove. In contrast, the link 54 is a separate member which carries the movable interconnection element in the present invention.

The arcuate flange 62 is formed by milling a semi-circular recess 74 in the upper distal portion of the link body 60. A separate recess 76 is milled in an inverted U-shape proximal to the flange 62 to receive the proximal portion of the movable jaw 52. A triangular portion 78 remains extending from the link body 60 to serve as a stop to limit the angle of opening of the movable jaw.

The link assembly 12 is shown in greater detail in Fig. 3. The left side of the stationary jaw 50 and the outer conduit 18 have been cut away for illustration purposes. The flange 62 of the link 54 is shown interlocked with a matching groove 80, shown in phantom, which is formed within the movable jaw 52. The stationary jaw 50 and the movable jaw 52 are pivotably interconnected by a pair of arcuate flanges and grooves, represented by arc 82, shown in phantom.

The stationary jaw 50 defines lower and upper slots 84, 86, respectively, through which movable jaw 52 and the link 54 are assembled and disassembled as described below. Also shown is a portion of a spacer 90 according to the present invention and an O-ring 92 which establishes a seal between the actuator rod 20 and the proximal cylindrical portion of the stationary jaw 50. Approximately one-eighth inch of the outer proximal surface of the stationary jaw 50 has been milled to fit within the distal end of the conduit 18.

A top view of the link assembly 12 with the link 54 removed is shown in Fig. 4. The actuating rod 20 in this

construction tapers from a large-diameter region 93 to a narrow diameter region 97 through a transition region 95. The actuator rod 20 terminates distally in a pair of fingers 94, 96 which define lateral openings 98, 100, respectively.

The interconnection of the link 54 with the distal fingers 94, 96 is schematically shown in Fig. 5. The convexly curved distal lead surfaces 102, 104 of the distal fingers 94, 96 are shown contacting the concave surfaces 68, 70 of the shoulder 66. The corresponding convex and concave surfaces enable unrestricted rise and fall of the link 54 relative to the actuator rod 20.

The projections 64, 65 have slanted proximal surfaces 106, 108 to assist insertion past the distal lead surfaces 102, 104 of the fingers 94, 96. Alternatively, the inner edges of the fingers 94, 96 are chamfered along the vertical axis as well as being convex along the horizontal axis.

During assembly, the movable jaw 52, Fig. 3, is inserted through upper slot 86 to engage the lower arcuate flange-and groove arrangement indicated as arc 82. After jaw 52 has been interconnected with the stationary jaw 50, the arcuate flange 62 of the link 54 is interconnected with the corresponding groove 80 of jaw 52. The link 54 is brought to rest in a horizontal position as shown in Fig. 3. The actuator rod 20 is then inserted distally through the conduit 18 so that a proximal shaft portion 110 of the link 54 slides between the distal fingers 94, 96 until the projections 64, 65 snap into the openings 98, 100.

During disassembly, the fingers 94, 96 must be spread apart so that the distal surfaces of the link projections 64, 65 clear the edges of the openings 98, 100. To accomplish this, a blade 112 having a rectangular or elliptical cross-section is inserted into the slot 72. The blade 112 is rotated to place the blade 112 perpendicular to the fingers 94, 96 which cams them apart as indicated in the phantom by lines 94a, 96a. The link 54 is then moved distally and upwardly to disengage it from the fingers 94a, 96a, or the actuating rod 20 is drawn proximally.

The transmission of actuation forces from actuating rod 20 to link 54 is shown schematically in Figs. 6A and 6B. When the actuating rod 20 is pulled proximally as shown by arrow 118, the distal surfaces 120, 122 of the link projections 64, 65 engage the distal surfaces of the finger openings 98, 100. The link 54 is thereby pulled proximally to open the jaw 52 relative to the stationary jaw 50.

The distal surfaces 120, 122 are curved in a preferred embodiment as shown in Fig. 2 even though they appear flat in cross-section as shown in Figs. 6A and 6B. Surfaces 120, 122 serve as first curvilinear surfaces for receiving the first, pulling actuating force.

Greater power is required during closing of the jaws. To accomplish the transfer of a large amount of closing force, the openings 98, 100 are somewhat oversized, especially along the longitudinal axis, to allow the

distal lead surfaces 102, 104 of the fingers 94, 96 to directly engage the shoulder curvilinear surfaces 68, 70 when the actuating rod 20 is pushed distally in the direction indicated by arrow 124.

Therefore, two different loci of force transfer, or alternating load-bearing surfaces, are accomplished with the present invention. Preferably, the force transfer surfaces are curved to facilitate the pivoting action of the link relative to the actuator.

The spacer 90, which is shown in previous figures but is omitted in Figs. 6A and 6B, is shown separately in greater detail in Fig. 7. The spacer 90 is comprised of a spacer body 130 having flattened lateral surfaces 132, 134 which contact the inner lateral surfaces of the distal fingers 94, 96. Upper and lower bearing surfaces 136, 138 respectively, extend over and under the fingers 94, 96 as illustrated in Fig. 4. The bearing surfaces 136, 138 are arcuate to match the curvature of the conduit 18.

The spacer 90 assists restriction of the vertical rise and fall motion occurring within the link assembly 12 to the link 54 alone. The spacer 90 therefore aligns and positions the actuating rod 20 relative to the outer conduit 18 and provides a bearing surface against the inner surface of the conduit 18. These advantages are achieved without relying on the O-ring 92. In fact, spacer 90 minimizes deformation of the O-ring to maintain a gas-tight seal.

Additionally, the spacer 90 occupies volume that would otherwise be empty to prevent trapping and build-up of debris or other material within the space between the fingers 94, 96. Where the fingers 94, 96 meet at a rounded junction, as in the present construction, the spacer 90 includes a proximal rounded projection 140, Fig. 7 which nestles into the junction to further occupy volume and to assist positioning on the spacer 90 relative to the fingers 94, 96.

Other configurations of spacer 90 will be apparent for other spatial relationships between the actuator 20 and the conduit 18. For example, upper and lower bearing surfaces 136, 138 can be extended toward each other to form a cylinder. One or more lateral slits can be provided to allow a spreading apart of the distal fingers of the actuator during disassembly.

Preferred approximate dimensions and materials for several components for one construction of the surgical instrument 10 are as follows. The jaws 50, 52 and the link 54 are formed of 17-4PH (precipitation hardness) stainless steel which is readily available commercially. The link 54 has an overall length of 1.245 cm (0.49 inch) and a maximum height of 0.229 cm (0.09 inch). The distal portion of the link 54 has a greatest width of 0.076 cm (0.030 inch) while the shoulder 66 has a maximum width of 1.473 cm (0.58 inch) and the proximal portion 110 has a width of 0.063 cm (0.025 inch). The link projections 64, 65 have an overall diameter of 0.076 cm (0.030 inch) and project approximately 0.025 cm (0.010 inch) from the sides of proximal portion 110. The notch 72 has a length of 0.102 cm (0.040

inch).

The actuator 20 is preferably formed of an elastic material such as custom 455 stainless steel available from Carpenter Stainless Steel of Reading, Pennsylvania. The elasticity allows repeated spreading and closing of the distal fingers 94, 96 to allow assembly and disassembly as desired. The actuator 20 has an overall length of approximately 37.846 cm (14.9 inch) while the fingers 94, 96 have an overall length of 0.787 cm (0.31 inch). The openings 98, 100 are 0.0787 cm (0.031 inch) diameter holes. The full-diameter portion 93 of the actuator member 20 is a rod having a diameter of 1.473 cm (0.58 inch) which tapers to narrow region 97 having a diameter of 1.829 cm (0.72 inch).

In other embodiments, the openings 98, 100 and the link projection 64, 65 can be oblong, elliptical, rectangular or square, or different combinations thereof. Further, the openings 98, 100 can be partial recesses rather than complete through-holes. The relative shapes of the link projection 64, 65 and the openings 98, 100 can be selected to limit the rise and fall of the link 54 relative to the actuator member 20. For example, flat surfaces can be provided at the corners of a rectangular square projection to engage the upper surface of a rectangular opening to limit upward pivoting motion.

To assist assembly and disassembly, the upper lateral surfaces of the fingers 94, 96 and/or the upper surface of the proximal portion 110 can be chamfered in the region of notch 72 to provide two "V" angles into which two blades can be inserted parallel to the fingers 94, 96 to assist spreading during disassembly.

The spacer 90 is formed of an acetal resin. It has an overall length of 0.437 cm (0.172 inch) and a diameter of 0.226 cm (0.089 inch). The spacer body 130 has a width of 0.058 cm (0.023 inch). The O-ring is formed of 95% silicone and 5% polytetrafluoroethylene ("PTFE"). Both the acetal resin and silicone/PTFE compositions have low coefficients of friction.

The conduit 18 is stainless steel tubing of 303 or 304 stainless steel. The handle arms 36, 26 and handle body are formed of 303 stainless steel.

The placement of a flange or a groove on the stationary member 50 in the position indicated as arc 82 in Fig. 3 depends upon the wall thickness of the jaw 50 and whether, during use, the walls tend to be forced apart from each other. A straight-sided flange placed on the outer stationary jaw member walls is preferred in most circumstances for ease of manufacture, but a dove-tail arrangement is useful to resist lateral spreading of the jaw walls.

The projections 64, 65 of link 54 are preferably formed integrally by milling with circular interpolation to form the projections. In other constructions, the projections 64, 65 can be established by a pin which is fitted through a hole in the side of proximal portion 110. The integrally-formed projections are desired because the problems of edge load of a pin on the rims of a hole are avoided. Edge load is particularly important for a

smaller-sized instruments.

An alternate link assembly suited for larger-sized instruments is shown in Figs. 8A and 8B. Link assembly 12a is an alternative hinge-type arrangement which includes a link 54a having a proximal portion 110a that lies against single distal finger 140 of an actuator member 20a. The actuator member 20a and the link 54a are pivotably interconnected by a pivot pin 142 which is threaded, pressed, or otherwise secured to the finger 140. A head 144 prevents the proximal portion 110a from separating laterally away from the finger 140. The proximal portion 110a defines an over-sized hole 146 which enables the alternate transmission of forces at different loci according to the present invention.

When actuator 20a is advanced toward the link 54a, the distal lead surface 148 contacts the proximal surface 150 of the shoulder 66a. When the actuator 20a is pulled proximally, the proximal surface of the hole 146 contacts the proximal surface 150 of the pin 142. The contacting surfaces 148, 150 are curved relative to each other as shown in Fig. 8B to provide unrestricted pivoting action.

An alternate link assembly 160 is shown in Figs. 9-10B having two links 162, 164 which are attached to movable jaws 166, 168, respectively. The link assembly 160 is shown in a closed position in top view in Fig. 9 and in side view in Fig. 10A. An actuator rod 170 reciprocates within an outer tube 172. Elliptical openings 174, 176 are defined in distal fingers 178, 180, respectively, of the actuator 170. A projection 182 of the link 162 extends into the opening 174 and a projection 184 of the link 164 extends into the opening 176. The links 162, 164 are interconnected at their center by a projection 186 of link 162 which extends into recess 188 of link 164.

In the closed position shown in Figs. 9 and 10A, the leading distal edges of the fingers 178, 180 contact corresponding shoulders 185, 187 of links 162, 164. The distal end of link 164 is interconnected with upper jaw 168 by a pin 190 whereas the link 164 is interconnected with lower jaw 166 by a pin 192. The jaws 166, 168 are interconnected with each other by a central pivot pin 194 which extends through corresponding holes in the outer tube 172. Pivot pins 190, 192 lie distal to the central pin 194 as indicated by arrow 196.

When the actuator 170 is pulled proximally, the link projections 182, 184 contact the proximal edges of the openings 174, 176 to drive jaws 166, 168 in opposite directions as shown in Fig. 10B. The pivot pins 190, 192 are pulled proximal to the central pin 194 as indicated by arrow 198.

Therefore, the reciprocation of a single actuator can drive two movable jaws when two links are used according to the present invention. As is exhibited in the previously-described embodiments, the actuator directly contacts shoulders of the links to drive the jaws to a closed position while separate projections on the links engage different portions of the actuator to drive the

jaws open.

5 An alternative link assembly 200, Figs. 11A-11B, includes a tang 202 of an actuator rod 204 which projects into a slot 205 defined by prongs 206, 208 of a link 210. The tang 202 carries projections 212, 214 which engage recesses 216, 218 of the prongs 206, 208. The link 210 defines one concave shoulder 220 at the junction of the prongs 206, 208 and two convex shoulders 222, 224 which are defined by the proximal ends of the prongs 206, 208. The actuator 204 defines matching convex surface 230 and concave surfaces 232, 234, respectively.

10 Yet another link assembly 240 is shown in Fig. 12 having a link 242 with a proximal portion 243 which defines a cavity 244 into which a tongue 246 of an actuator 248 is inserted. The tongue 246 defines curvilinear projections 250, 252 that fit within matching recesses 254, 256, respectively. Curvilinear link surfaces 255, 257 of the proximal portion 243 engage the actuator projections 250, 252 when a first, pulling actuating force is applied to the actuator 248.

15 The recesses 254, 256 are somewhat oversized, at least in the longitudinal direction, to enable the projections 250, 252 to move distally when the actuator 240 is pushed in the opposite direction. The shoulders 258, 260 of the link 242 then contact matching surfaces 262, 264, respectively, of actuator 248. The pairs of surfaces 258, 260 and 262, 264 are correspondingly concave and convex, or convex and concave.

20 The link assembly 240 is assembled and disassembled in a bayonet-type fashion: a cavity 244 is sloped and twisted so that the actuator 248 must be rotated ninety degrees during insertion and removal.

25 Figs. 13 and 14A-14B illustrate two additional embodiments in which a link is insertable into an actuator rod and vertical rise and fall is restricted to the link. Both links define a proximal element having a first curvilinear face for pivotably engaging a first surface of an actuating member to transmit a first actuating force from the actuating member to a work member such as a movable jaw. The proximal element also has a second curvilinear face for pivotably engaging a second surface of the actuating member to transmit a second, greater actuating force applied to the actuating member in direction opposite to that of the first actuating force to transmit the second force to the work member.

30 40 Link assembly 270, Fig. 13, has a link 272 which pivotably engages an actuator 274. The link 272 has an arcuate flange 276 which engages an arcuate groove 278 of the actuator 274. The link 272 further includes a distal interconnection element such as arcuate flange 284 as shown.

45 50 The arcuate groove 278 extends laterally from a slot 286 in the actuator 274 which enables distal sections 290, 292 to spread apart to receive the proximal end of the link 272 so that it can be longitudinally snapped into the actuator 274. A portion of a proximal shoulder face 280 of the link 272 or a leading edge 294

of the actuator 274 can be chamfered to assist the insertion of the link 272 into the actuator 274.

The distal surface of the groove 278 contacts the first curvilinear link face 285 to transmit a first, pulling actuating force. The proximal surface of the groove 278 contacts the second curvilinear link face 280 to transmit the second, greater pushing actuating force.

A channel 283 has a sufficient length along the longitudinal axis to maintain the proximal face 287 of the link body 289 away from the distal face 282 of the link 274. Alternatively, the channel 283 is shorter to allow the face 287 to serve as a shoulder to receive the pushing actuation force. In the alternative construction the face 282 is concave, as indicated in phantom by edge line 294a.

The slot 286 is exaggerated for the purposes of illustration; preferably it is narrow and located relative to the central longitudinal axis of the actuator 274 so that force is directed as on-center as possible to the proximal face 280 of the link 272.

Link assembly 300, Figs. 14A-14B, comprise a link 302 having a substantially spherical, ball-like proximal end 306 which is insertable into recess 308 of an actuator 304. The spherical end 306 includes a first curvilinear surface 310 and a second curvilinear surface 312 which contacts the distal and proximal surfaces of spherical chamber 314 extending from the recess 308. The spherical end 306, also referred to as a protuberance, has flat surfaces 316, 318 which slide past flattened surfaces 320, 322, respectively, at the entrance to the recess 308. Once the link 302 is inserted so that the protuberance 306 has entered the chamber 314, the link 302 is rotated ninety degrees to the position shown in Fig. 14B.

The link 302 is formed as an integral piece which initially has an outer diameter corresponding to that of the protuberance 306. A main shaft 324 is ground down by milling, followed by formation of shaft 326 which terminates in arcuate flange 328 for interconnection with a work member such as a movable jaw. The recess 308, including the chambers 314 and 330, are formed by boring. This embodiment further includes a spring chamber 330 in which a spring 332 is disposed to minimize possible vibrations and to improve the "feel" of the instrument during actuation. Preferably, different alloys of stainless steel are used as the materials for the above-identified components when used in a surgical instrument.

During actuation, a pulling force is transmitted to the link 302 by contact with the first surface 310, and a second greater force can be transmitted to the link 302 by contact of the proximal surface of the chamber 314 with the second curvilinear surface 312. Alternatively, a shoulder 334, shown in phantom, can be added to contact the distal face 336 of the actuator 304 to transmit the pushing force. Preferably, both the proximal surface of the shoulder 334 and the face 336 are curved in a mating fashion to facilitate vertical rise and fall of the link

302. The chamber 314 in the alternative construction is sufficiently oversized, at least in the longitudinal direction, to enable contact between the proximal surface of the shoulder 334 and the distal actuator face 336.

5 Although specific features of the invention are shown in some drawings and not in others, this is for convenience only as each feature may be combined with any or all of the other features in accordance with the invention.

10 Other embodiments will occur to those skilled in the art and are within the following claims.

#### Claims

15 1. A link (54) for transmitting actuating forces from an actuating member (20) to a work member (52) comprising:

20 a link body (60) having a distal end and a proximate end;

25 distal means disposed proximate to said distal end of said link body, for movably interconnecting said link body with the work member, wherein said distal means for interconnecting is selected from the group consisting of an arcuate flange (62), an arcuate groove (80), and a pivot (142);

30 proximal means disposed to said proximal end of said link body (60), for pivotally interconnecting said link body (60) with the actuating member (20), and for transmitting a first actuating force from the actuating member (20) to the work member (5)

35 characterized in that said link body (60) is provided with a shoulder (66) formed as an integral part of said link body (60) longitudinally spaced from said proximal means for interconnecting, for engaging a distal region of the actuating member (20) when a second, greater actuating force (124) is applied to the actuating member (20) in a direction opposite to that of said first actuating force (118) to transmit said second force (124) to the work member (52), said shoulder including at least one lateral projection (64,65) extending from a side of said link body (60), said projection (64) defining a proximal end face (106) engageable with the distal region of the actuating member (20).

40 50 2. The link (54) of claim 1 in which said proximal means for interconnecting is one of (a) at least one projection (64,65) capable of fitting within a corresponding recess in the actuating member (20) and (b) at least one recess (98,100) for accepting a corresponding projection (64,65) of said actuating member (20).

55 3. The link (54) of any preceding claim in which said

shoulder (66) is attached to said link body (60) between said distal and proximal means for interconnecting.

4. The link (54) of any preceding claim in which said proximal means for interconnecting is constructed to transmit a pulling force from the actuating member (20) to drive the work member (52) proximally toward the actuating member (20), and said shoulder (66) is configured to transmit a pushing force toward the work member (52) to drive the work member (52) distally. 5
5. The link (54) of any preceding claim in which said shoulder (66) is formed as an integral part of said body (60) and said shoulder (66) includes lateral projections (64,65) extending from either side of said link body (60), each projection (64,65) defining a curvilinear proximal end face (68,70). 10
6. The link (54) of any preceding claim further including a stop element (78), associated with said distal means for interconnecting, for limiting movement of the work member (52) relative to said link (54). 15
7. Assembly (12) of the link (54) together with the actuating member (20) of any preceding claim, said actuating member (20) including at least one distally projecting finger (94,96), said finger (94,96) having a distal lead surface which serves as said distal region for engaging said shoulder (66) of said link (54), and said finger (94,96) further defining a recess (98,100) proximal to said distal lead surface for interlocking with said proximal means for pivotably interconnecting. 20
8. Assembly of Claim 7 in which said actuating member (20) includes two spaced distally projecting fingers (94,96), said shoulder (66) includes lateral projections (64,65), each projection (64,65) defining a concave proximal end face, and each finger (94,96) having a matching convex distal lead surface, said proximal means for interconnecting includes a projection (64,65) extending from either side of said link body (60) and each said distal finger (94,96) includes a corresponding recess (98,100) for receiving the respective projection (94,96), and said distal means and said proximal means are formed integrally with said link body. 25
9. The link (54) of any preceding claim together with the following components of a surgical instrument: 30
  - a first movable jaw member (52) as the work member;
  - a second jaw member (50);
  - a conduit (18) having an inner passage extending through it; and

the actuating member (20) being slidably disposed within said conduit (18).

#### Patentansprüche

1. Verbindungsstück (54) zum Übertragen von Betätigungskräften von einem Betätigungsglied (20) zu einem Arbeitsglied (52), umfassend:

einen Verbindungsstück-Körper (60) mit einem distalen Ende und einem proximalen Ende, eine distale Einrichtung, die benachbart dem distalen Ende des Verbindungsstück-Körpers angeordnet ist, um den Verbindungsstück-Körper bewegbar mit dem Arbeitsglied zu verbinden, wobei die distale Einrichtung zum Verbinden ausgewählt ist aus der Gruppe bestehend aus einem bogenförmigen Flansch (62), einer bogenförmigen Nut (80) und einer Drehachse (142),

eine proximale Einrichtung, die an dem proximalen Ende des Verbindungsstück-Körpers (60) angeordnet ist, um den Verbindungsstück-Körper (60) drehbar mit dem Betätigungslied (20) zu verbinden und zum Übertragen einer ersten Betätigungs Kraft vom Betätigungslied (20) zum Arbeitsglied (52),

dadurch gekennzeichnet, daß der Verbindungsstück-Körper (60) mit einer Schulter (66) versehen ist, die als ein integraler Teil des Verbindungsstück-Körpers (60) in Längsrichtung im Abstand von der proximalen Einrichtung zum Verbinden ausgebildet ist, zum Eingriff einer distalen Region des Betätigungsliedes (20), wenn eine zweite größere Betätigungs Kraft (124) in einer der ersten Betätigungs Kraft (118) entgegengesetzten Richtung auf das Betätigungslied (20) ausgeübt wird, um die zweite Kraft (124) auf das Arbeitsglied (52) zu übertragen, wobei die Schulter mindestens einen seitlichen Vorsprung (64,65) einschließt, der sich von einer Seite des Verbindungsstück-Körpers (60) aus erstreckt, wobei der Vorsprung (64) eine proximale Endfläche (106) bildet, die mit der distalen Region des Betätigungsliedes (20) in Eingriff bringbar ist

2. Verbindungsstück (54) nach Anspruch 1, bei dem die proximale Einrichtung zum Verbinden eine ist aus (a) mindestens einem Vorsprung (64,65), der in eine entsprechende Ausnehmung im Betätigungslied (20) einpaßbar ist und (b) mindestens eine Ausnehmung (98,100) zur Aufnahme eines entsprechenden Vorsprunges (64,65) des Betätigungsliedes (20).
3. Verbindungsstück (54) nach einem vorhergehenden Anspruch, bei dem die Schulter (66) zwischen

der distalen und der proximalen Einrichtung zum Verbinden an dem Verbindungsstück-Körper (60) angebracht ist.

4. Verbindungsstück (54) nach einem vorhergehenden Anspruch, bei dem die proximale Einrichtung zum Verbinden derart konstruiert ist, daß sie eine Zugkraft vom Betätigungsglied (20) überträgt, um das Arbeitsglied (52) proximal zum Betätigungs-glied (20) hin anzureiben, und wobei die Schulter (66) derart konfiguriert ist, daß sie eine Stoßkraft gegen das Arbeitsglied (52) überträgt, um das Arbeitsglied (52) distal anzureiben.
5. Verbindungsstück (54) nach einem vorhergehenden Anspruch, worin die Schulter (66) als ein integraler Teil des Körpers (60) ausgebildet ist, und die Schulter (66) seitliche Vorsprünge (64,65) einschließt, die sich von jeder Seite des Verbindungsstück-Körpers (60) aus erstrecken, wobei jeder Vorsprung (64,65) eine gekrümmte, proximale Endfläche (68,70) bildet.
6. Verbindungsstück (54) nach einem vorhergehenden Anspruch, das weiter ein Anschlagelement (78) einschließt, das in Verbindung steht mit der distalen Einrichtung zum Verbinden, um die Bewegung des Arbeitsgliedes (52) mit Bezug auf das Verbindungsstück (54) zu begrenzen.
7. Baueinheit (12) des Verbindungsstückes (54) zusammen mit dem Betätigungs-glied (20) nach einem vorhergehenden Anspruch, wobei das Betätigungs-glied (20) mindestens einen distal vorspringenden Finger (94,96) einschließt, der Finger (94,96) eine distale vordere Oberfläche aufweist, die als die distale Region zum Eingriff der Schulter (66) des Verbindungsstückes (54) dient, und der Finger (94,96) weiter eine Ausnehmung (98,100) proximal zu der distalen vorderen Oberfläche zum Ineinandergreifen mit der proximalen Einrichtung zum drehbaren Verbinden bildet.
8. Baueinheit nach Anspruch 7, bei der das Betätigungs-glied (20) zwei beabstandete, distal vorspringende Finger (94,96) einschließt die Schulter (66) seitliche Vorsprünge (64,65) einschließt, wobei jeder Vorsprung (64,65) eine konkave proximale Endfläche bildet und jeder Finger (94,96) eine passende konvexe distale vordere Oberfläche aufweist, die proximale Einrichtung zum Verbinden einen Vorsprung (64,65) einschließt, der sich von jeder Seite des Verbindungsstück-Körpers (60) aus erstreckt, und jeder distale Finger (94,96) eine entsprechende Ausnehmung (98,100) zur Aufnahme des entsprechenden Vorsprunges (94,96) einschließt, und die distale Einrichtung und die proximale Einrichtung integral mit dem

Verbindungsstück-Körper ausgebildet sind.

9. Verbindungsstück (54) nach einem vorhergehenden Anspruch zusammen mit den folgenden Komponenten eines chirurgischen Instrumentes:

einer ersten bewegbaren Backe (52) als dem Arbeitsglied,  
einer zweiten Backe (50),  
einem Rohr (18) mit einem sich hindurchstreckenden, inneren Durchgang, und dem verschiebbar in dem Rohr (18) angeordneten Betätigungs-glied (20).

#### 15 Revendications

1. Élément (54) pour transmettre des forces de commande, à partir d'un organe de commande (20), à un organe de manœuvre (52), comportant :

- un corps d'élément (60) présentant une extrémité distale et une extrémité proximale,
- des moyens distaux disposés près de l'extrémité distale du corps d'élément pour relier de façon mobile ledit corps d'élément à l'organe de manœuvre, ces moyens de liaison distaux étant choisis dans le groupe comprenant une bride arquée (62), une rainure arquée (80) et un pivot (142),
- des moyens proximaux disposés à l'extrémité proximale du corps d'élément (60) pour relier de manière pivotante ledit corps d'élément (60) à l'organe d'actionnement (20) et pour transmettre une première force de commande, à partir de l'organe de commande (20), à l'organe de manœuvre (52).

caractérisé en ce que le corps d'élément (60) est pourvu d'un épaulement (66) conçu comme une partie solidaire du corps d'élément (60), espacée longitudinalement des moyens de liaison proximaux, afin de venir en contact avec une zone distale de l'organe de commande (20) lorsqu'une seconde force de manœuvre (124), plus grande, est appliquée à celui-ci dans une direction opposée à celle de la première force de manœuvre (118), afin de transmettre la seconde force (124) à l'organe de manœuvre (52), l'épaulement comportant au moins une saillie latérale (64, 65) qui part d'un côté du corps d'élément (60), la saillie (64) définissant une face d'extrémité proximale (106) apte à venir en contact avec la zone distale de l'organe de commande (20).

2. Élément (54) selon la revendication 1, dans lequel les moyens de liaison proximaux consistent en (a) au moins une saillie (64, 65) apte à s'emboîter dans un creux correspondant de l'organe de commande

(20), et (b) au moins un creux (98, 100) destiné à recevoir une saillie correspondante (64, 65) de l'organe de commande (20).

3. Elément (54) selon l'une quelconque des revendications précédentes, dans lequel l'épaulement (66) est fixé au corps d'élément (60) entre les moyens de liaison distaux et proximaux. 5

4. Elément (54) selon l'une quelconque des revendications précédentes, dans lequel les moyens de liaison proximaux sont conçus pour transmettre une force de traction, à partir de l'organe de commande (20), afin de déplacer l'organe de manœuvre (52) vers le côté proximal, en direction de l'organe de commande (20), et l'épaulement (66) est formé de manière à transmettre une force de poussée vers l'organe de manœuvre (52) afin de déplacer celui-ci vers le côté distal. 10

5. Elément (54) selon l'une quelconque des revendications précédentes, dans lequel l'épaulement (66) est conçu comme une partie solidaire du corps (60) et comprend des saillies latérales (64, 65) qui partent de chaque côté du corps d'élément (60), chaque saillie (64, 65) définissant une face d'extrémité proximale curviligne (68, 70). 15

6. Elément (54) selon l'une quelconque des revendications précédentes, comportant également un élément d'arrêt (78), associé aux moyens de liaison distaux, pour limiter le mouvement de l'organe de manœuvre (52) par rapport à l'élément (54). 20

7. Ensemble (12) formé de l'élément (54) et de l'organe de commande (20) selon l'une quelconque des revendications précédentes, étant précisé que l'organe de commande (20) comporte au moins une tige (94, 96), saillant côté distal, qui présente une surface de guidage distale qui sert de zone distale pour venir en contact avec l'épaulement (66) de l'élément (54), la tige (94, 96) définissant également un creux (98, 100) proximal par rapport à la surface de guidage distale, prévu pour un blocage mutuel avec les moyens de liaison proximaux pivots. 25

8. Ensemble selon la revendication 7, dans lequel l'organe de commande (20) comporte deux tiges espacées (94, 96) saillant côté distal, l'épaulement (66) comporte des saillies latérales (64, 65), chaque saillie (64, 65) définissant une face d'extrémité proximale concave tandis que chaque tige (94, 96) a une surface de guidage distale convexe adaptée, les moyens de liaison proximaux comportent une saillie (64, 65) qui part de chaque côté du corps d'élément (60) et chaque tige distale (94, 96) comporte un creux correspondant (98, 100) destiné à 30

9. Elément (54) selon l'une quelconque des revendications précédentes, associé aux éléments suivants d'un instrument chirurgical : 35

- un premier organe formant mâchoire mobile (52), comme organe de manœuvre,
- un second organe formant mâchoire (50),
- un conduit (18) traversé par un passage intérieur, et
- l'organe de commande (20) disposé, coulissant, à l'intérieur du conduit (18).

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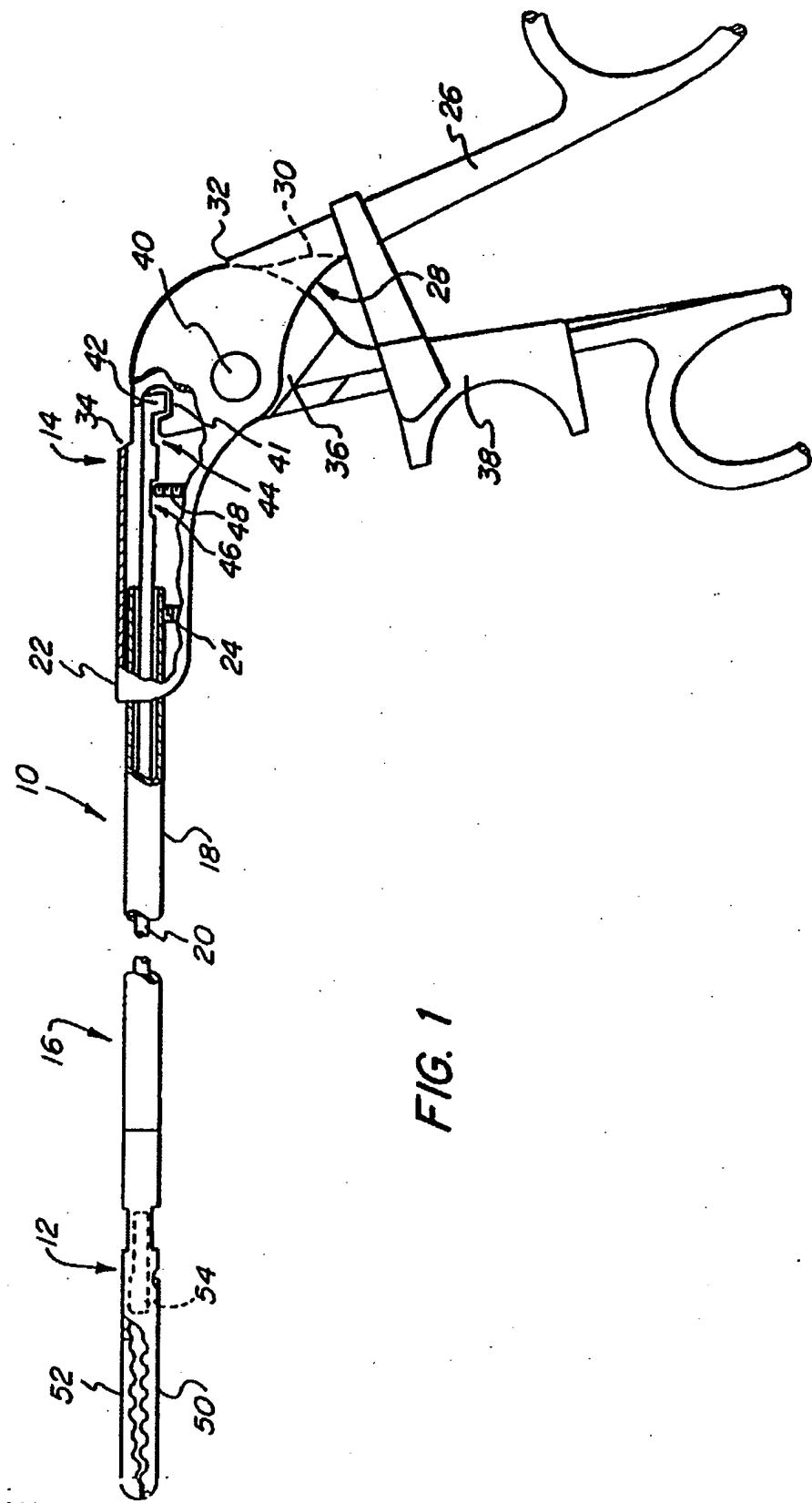
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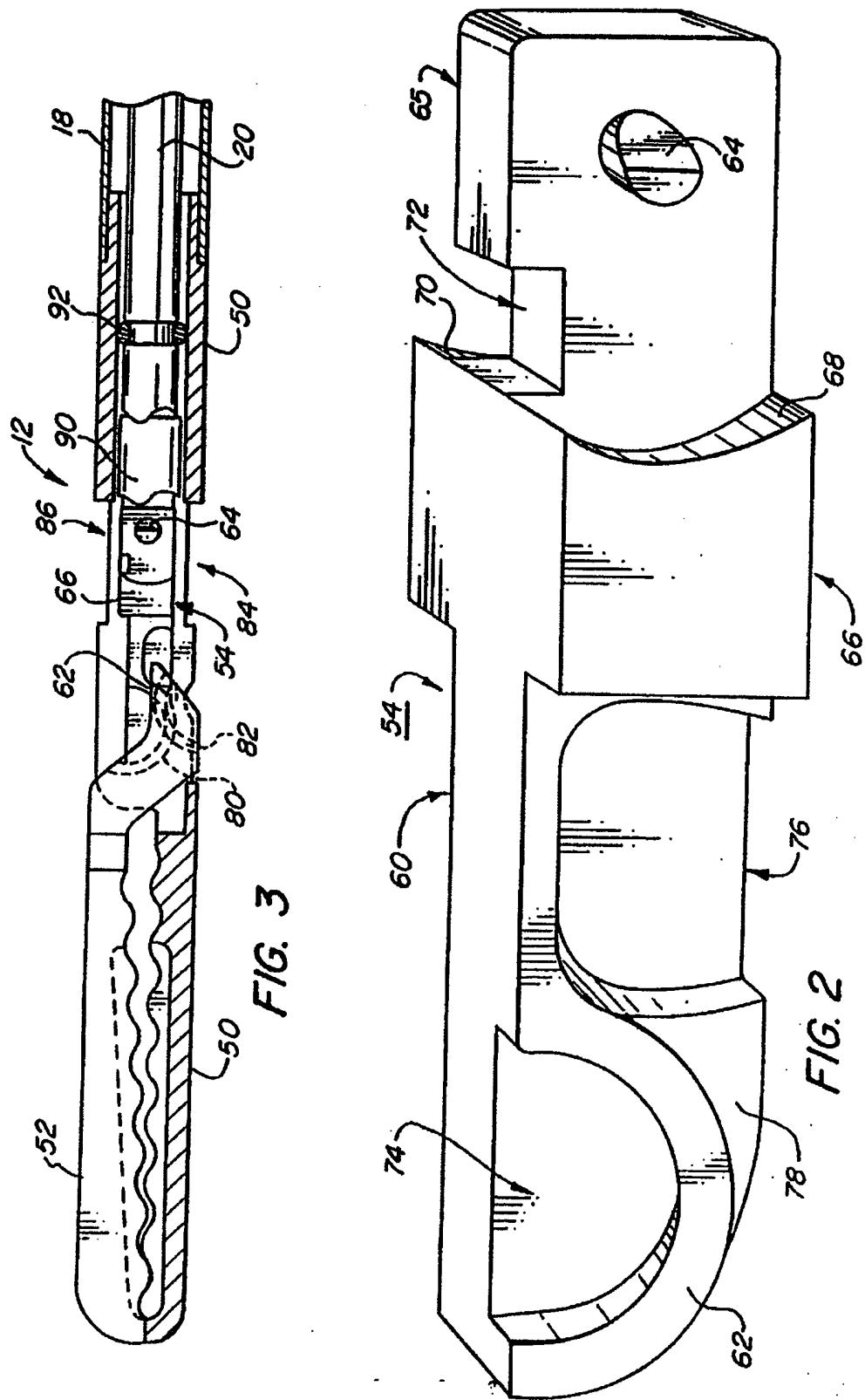
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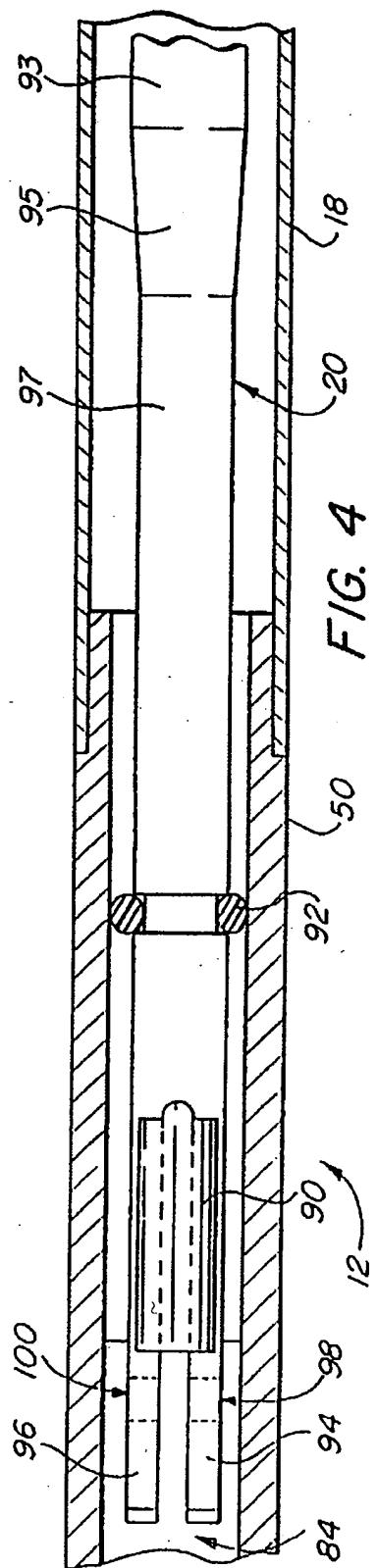
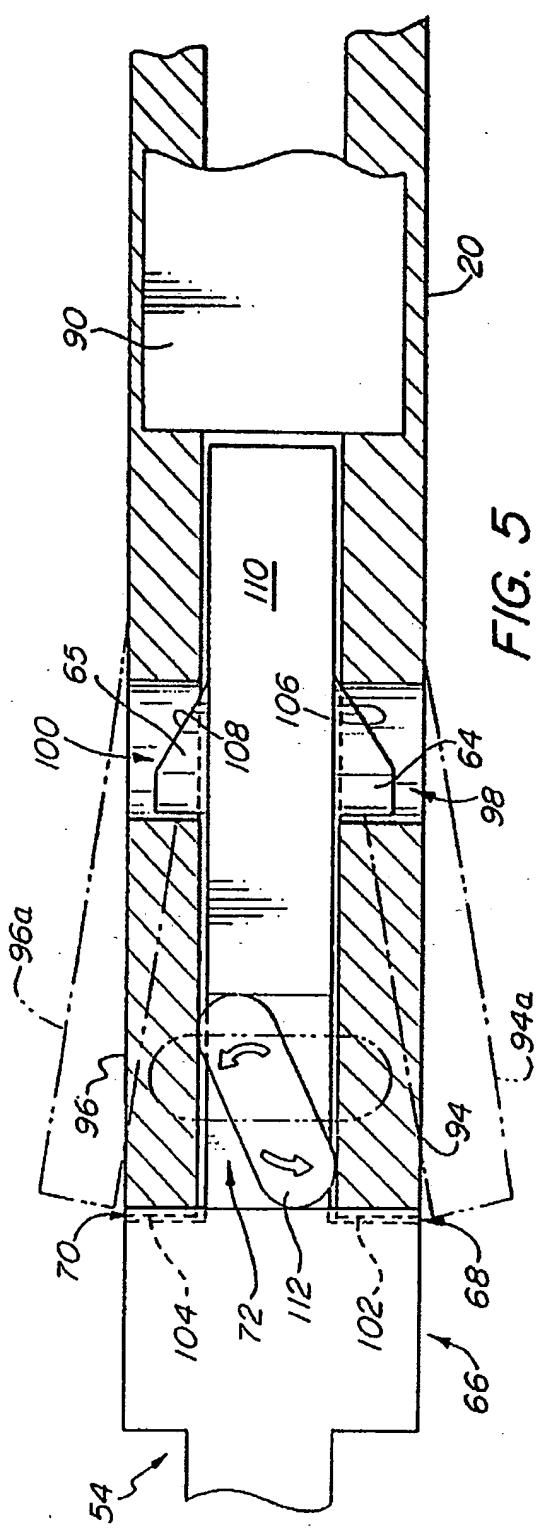
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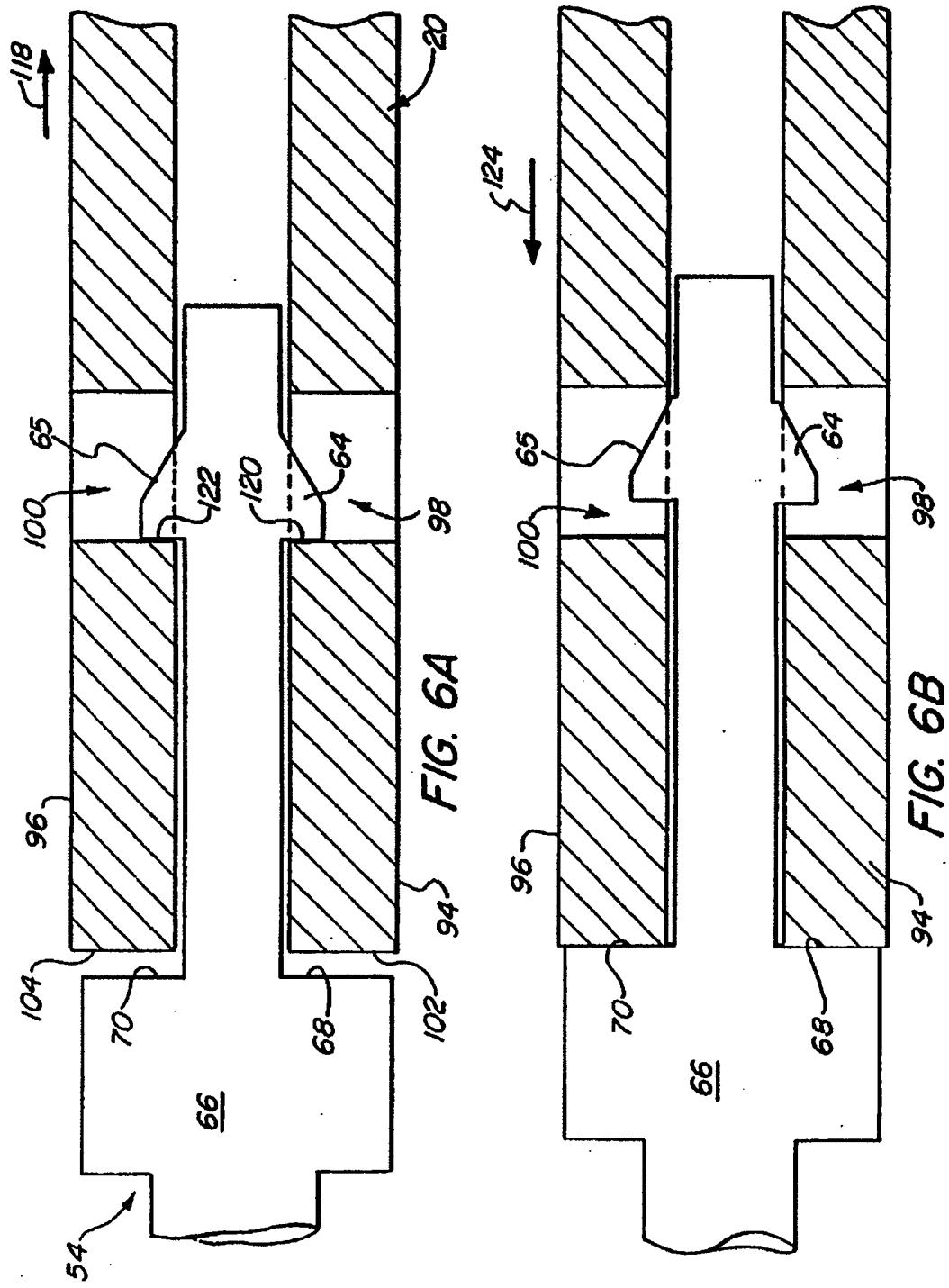
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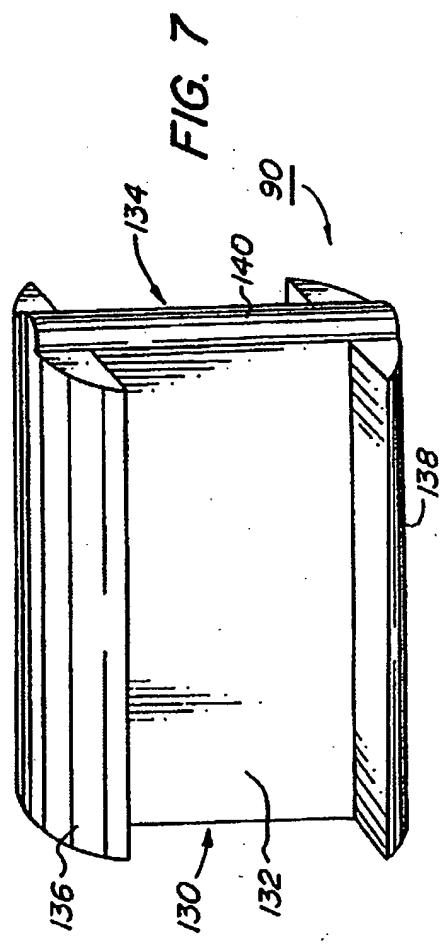
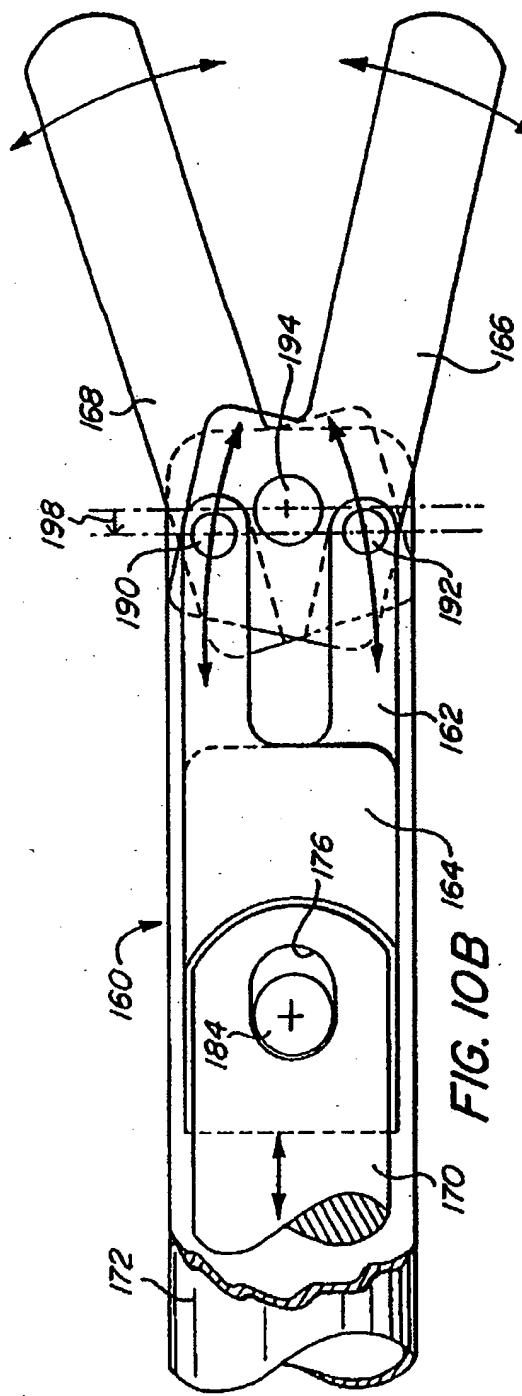
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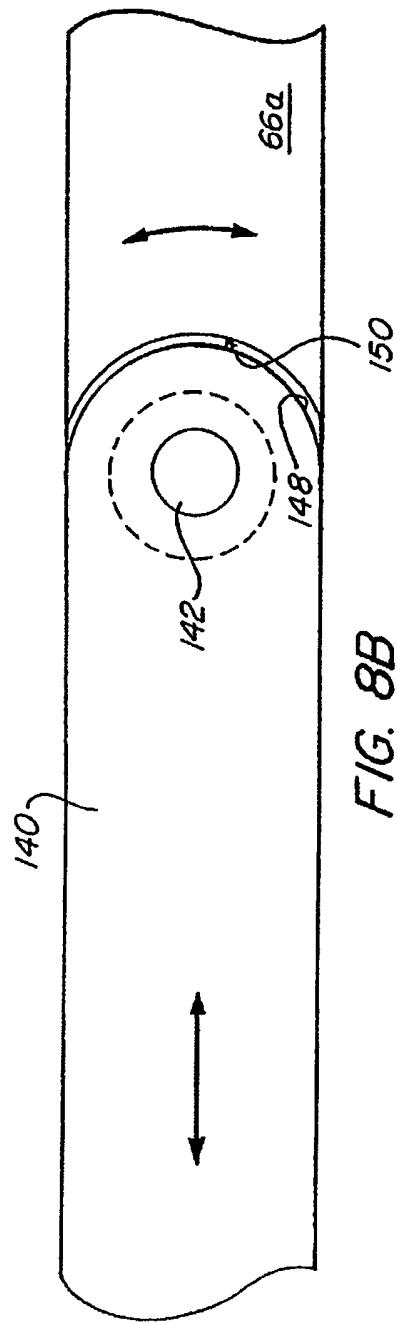
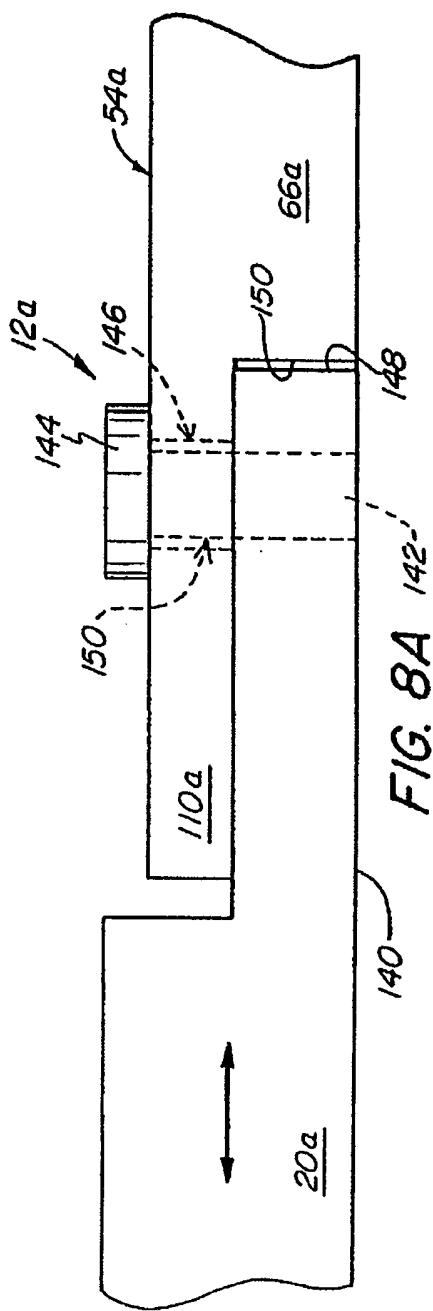












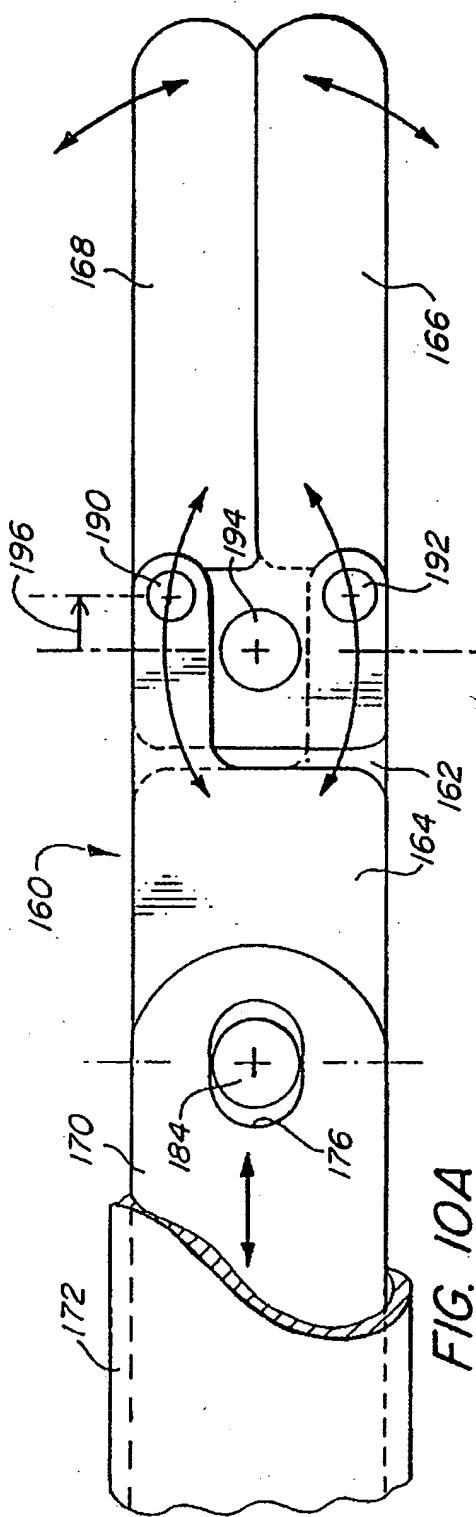


FIG. 10A

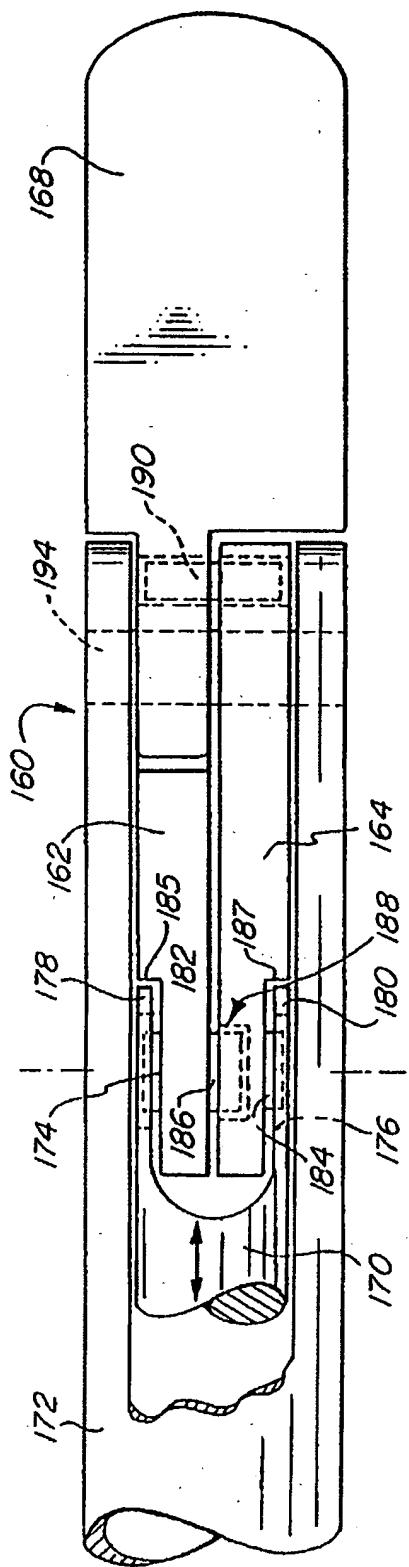
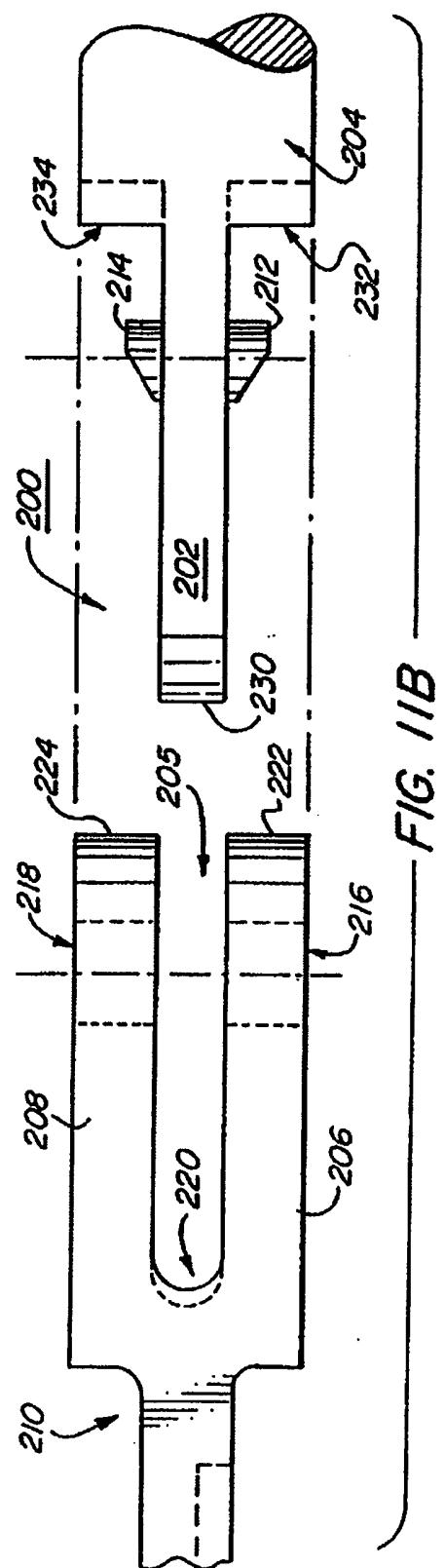
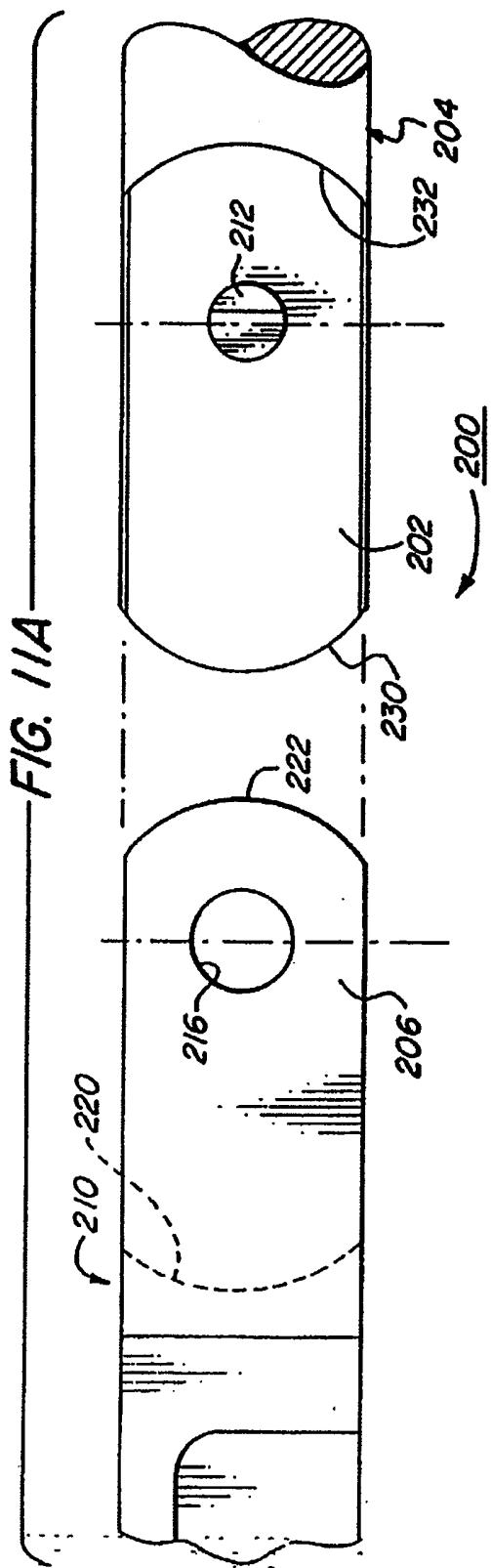
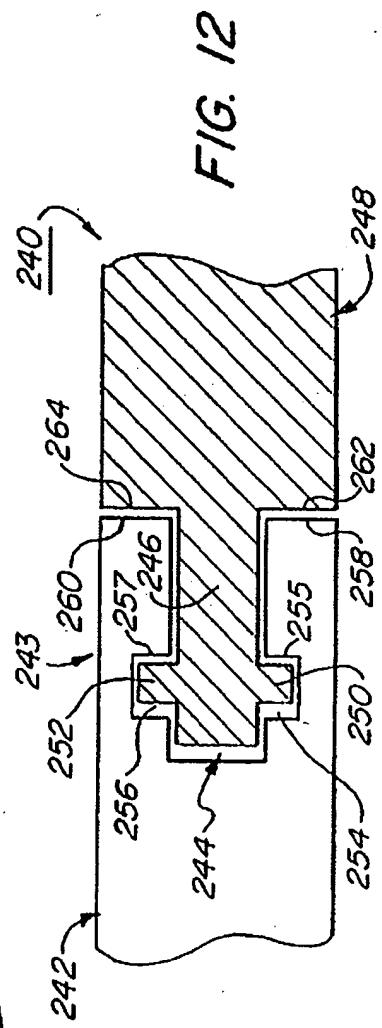
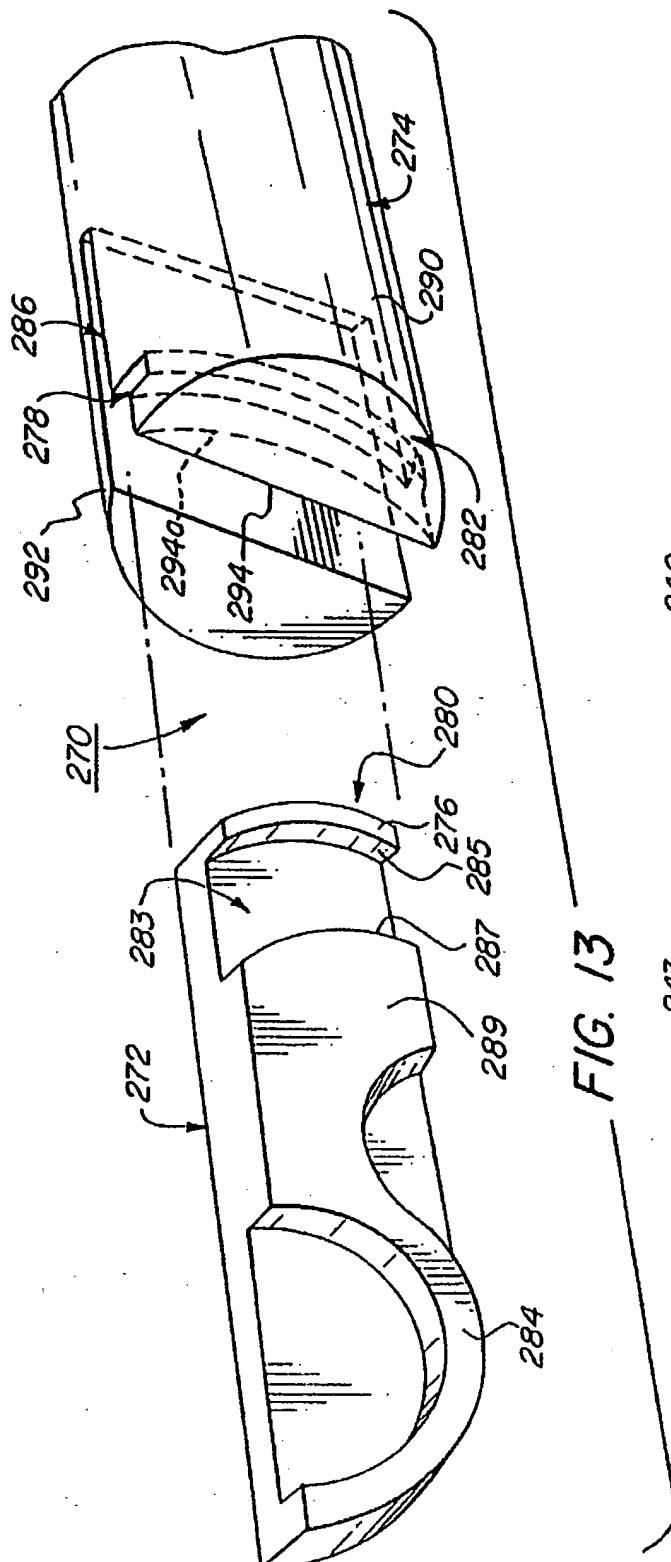
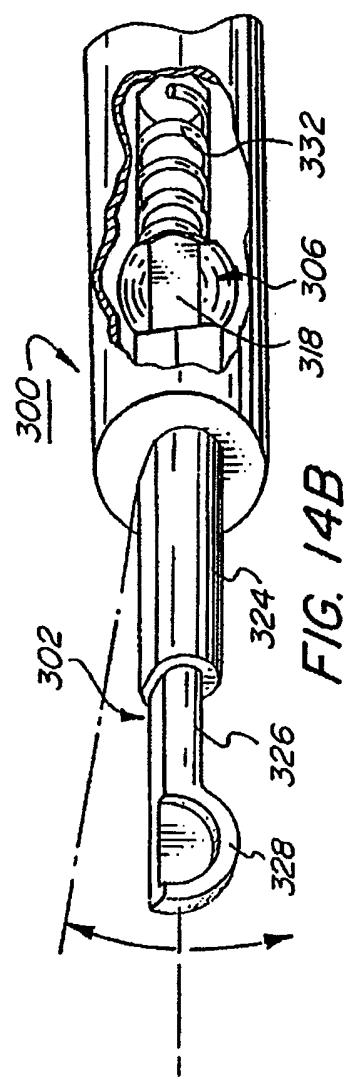
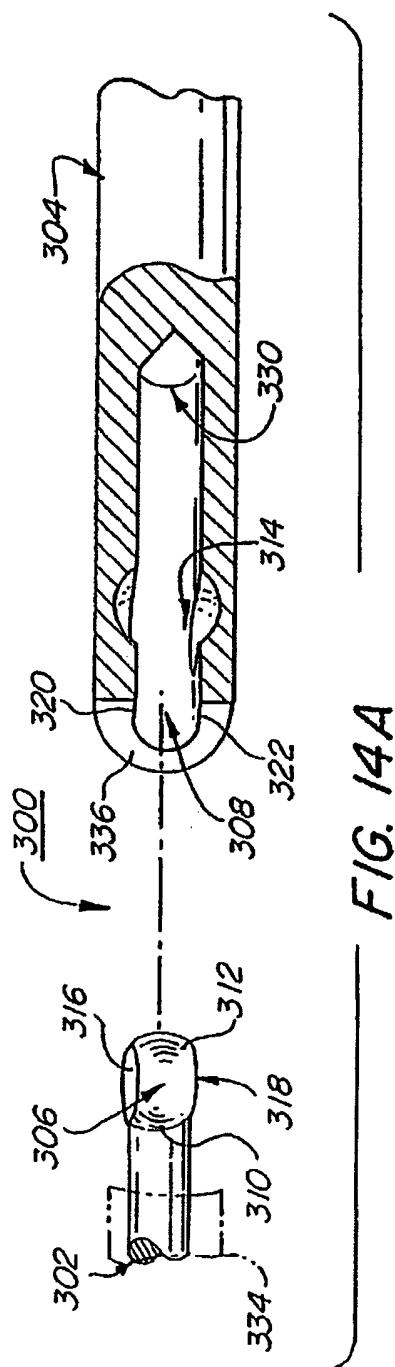


FIG. 9







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